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Insect-Caused Cone and Seed Losses in Treated and Untreated Loblolly Pine Seed Orchards

Carl W. Fatzinger,[1] Harry O. Yates III,[1] William J. Hammond,[2] and Roy Hutto[3]

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ABSTRACT

Differences in strobilus survival and yields of viable seed were estimated between ramets of the same four clones of loblolly pine, Pinus taeda L., in two differently managed seed orchards. One orchard had been treated with insecticides, fertilizers, and various cultural practices for a number of years, whereas the other orchard had not been treated with chemicals or cultural practices, other than mowing, for more than 8 years. Sample ramets in the treated orchard produced significantly more female flowers during 1979 and 1980 than did those in the untreated orchard. During 1980, the webbing coneworm, Dioryctria disclusa Heinrich, destroyed 33.5 percent of the second-year strobili in the treated orchard but not in the untreated orchard. Other species of coneworms, however, damaged more than twice as many strobili on the untreated ramets than on the treated ramets. The more intensive management practiced in the treated orchard resulted in increased strobilus production and survival as well as increased yields of viable seed per cone.

Keywords: Dioryctria disclusa, Leptoglossus corculus, Tetyra bipunctata, Pinus taeda, coneworms, pest management.

Seed is produced in southern pine seed orchards[4] by trees selected for increased growth, yield, and resistance to disease. Most of these orchards are intensively managed to maximize seed production through the use of pesticides, fertilizers, and cultural practices (Fatzinger and Miller 1980). Five insecticides are registered for control of destructive cone and seed insects, and the annual costs of control range up to about $495 per ha, depending on the insecticide used, the frequency of application, and the costs of labor, equipment, and fuel.

Insecticide effectiveness usually is determined by comparing rates of insect damage in treated and untreated trees located within the same orchard. Insect damage in operational orchards is minimized by using as few untreated trees as possible and by discontinuing insecticide treatments of these trees only a few months before the test. Applications of registered and experimental insecticides to the remainder of an orchard also are facilitated by confining the untreated trees to small, isolated areas of the orchard. Under these conditions, the numbers of destructive and beneficial insects within untreated areas could be altered; e.g., insecticides could decrease insect populations throughout the orchard or repel them from treated into untreated areas. Further bias could result from accidental contaminations of untreated trees with insecticides from spray drift, residues of previous insecticide applications, or systemic insecticides transported by soil water or root grafts.

[1]Research Entomologists, Southeastern Forest Experiment Station, Olustee, FL, and Athens, GA, respectively.

[2]Research Forester, Westvaco Corporation, Summerville, SC.

[3]Tree Improvement Supervisor, International Paper Company, Georgetown, SC.

[4]Seed orchard is a plantation consisting of clones or seedlings from selected trees and cultured for early and abundant seed production (Bramlett and others 1977). A clone is a group of genetically identical plants (called ramets) derived asexually from a single individual (Snyder 1972).

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This study compares insect damage in two loblolly pine, Pinus taeda L., seed orchards. One orchard had received no chemical or cultural treatments, other than annual mowing during June and October, for more than 8 years; the second orchard had been treated for several years with insecticides, fertilizers, and cultural practices such as mowing about five times per year, infrequent subsoiling, and pruning or thinning to optimize orchard productivity. Both orchards were growing on similar sites about 5 km apart near Georgetown, SC.

Methods

Survival of strobili[5] was compared from April 1979 to September 1980 in the treated and untreated loblolly pine seed orchards. The fertilizer and insecticide[6] treatments were continued only in the previously treated orchard. Four of the same clones were represented in both orchards, with ramets averaging 38.1 cm in d.b.h. and heights of 16 m in the treated orchard and 21 m in the untreated orchard. Two ramets from each of these clones were randomly selected within each orchard for use as sample trees. The ages of the sample trees ranged from 14 to 21 years in the treated orchard and from 20 to 21 years in the untreated orchard.

The untreated orchard was 0.8 ha and had been thinned to a variable spacing with about 133 trees/ha in 1971. However, it again appeared to be overstocked in 1979 with branches of adjacent trees partially closed together and only the uppermost branches producing female strobili.

The treated orchard was 11.5 ha, and trees were spaced 12.2 m by 12.2 m (ca. 69 trees/ha). The crowns of adjacent trees had not closed together, and female strobili were present through-out most of the upper two-thirds of the crowns. Fertilizer (potassium chloride plus ammonium nitrate) was applied during the late summer of 1978, and ammonium nitrate again was applied during 1979 and 1980. The insecticide carbofuran (Furadan®) was applied during the early spring of 1979 and 1980 for control of the seed bugs, Leptoglossus corculus (Say) and Tetyra bipunctata (Herrich-Schäffer), and coneworms, Dioryctria spp., by incorporating a granular formulation (10 percent AI) into the soil at a rate of 89.3 g/cm of tree d.b.h. A 0.2 percent AI aqueous solution of azinphos-methyl (Guthion®) also was applied to the tree crowns with a hydraulic sprayer for supplemental control of coneworms in July 1979 and during May and June 1980.

All clusters of newly emerged female flowers present in the southeastern quadrant of the crown were tagged on each sample tree during 1979 and 1980. The flowers tagged in 1979 were observed six times over the 2-year period of strobilus development to record causes of damage and mortality, whereas strobili tagged in 1980 were observed only three times during their first year of development. In October 1980, seeds were extracted from groups of mature sample cones collected from each tagged cluster. The average number of seed per cone was estimated for each group of cones, and the seed were radiographed to determine quality and germinated to determine viability.

An analysis of variance was used to test for significant differences between treatment means for: (1) number of female flowers produced per tree, (2) the percentages of damaged or destroyed strobili and seed, and (3) the percentage of seed germinated. Before analysis, the percentage data were transformed to arc sine $\sqrt{\text{proportion}}$, but only untransformed percentages are listed in the tables and results.

Results and Discussion

The numbers of female flowers produced during 1979 and 1980 by sample

[5] In this paper, the female reproductive structures of loblolly pine (flowers, conelets, and cones) are collectively referred to as "strobili" hereafter.

[6] The use of proprietary names is for identification purposes only and does not constitute an official endorsement by the U.S. Department of Agriculture. This publication reports research involving pesticides. It does not contain recommendations for their use, nor does it imply that the uses discussed here have been registered. All uses of pesticides must be registered by appropriate State and/or Federal agencies before they can be recommended.

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trees were significantly different ($P < 0.01$) between the two orchards. Over the 2-year period, the southeastern quadrants of sample trees produced an average of 75.4 ± 13.8 (SE) flowers in the treated orchard and only 40.7 ± 5.1 in the untreated orchard. These differences were not surprising because sample trees in the untreated orchard produced female strobili only on their uppermost branches, and they had not been treated with fertilizers or other cultural practices.

The webbing coneworm, D. disclusa Heinrich, unexpectedly destroyed 33.5 percent of the second-year strobili on sample trees in the treated orchard during the early spring of 1980 (table 1). This insect, however, did not damage second-year strobili on sample trees in the untreated orchard or first-year strobili on sample trees in either orchard. The absence of damage by the webbing coneworm on second-year strobili in the untreated orchard was unusual in view of its extensive damage in numerous other orchards throughout the Southeastern United States during 1980 (DeBarr and others 1982). The percentages of strobili damaged by coneworms other than the webbing coneworm were significantly different, with more than twice as much damage in the untreated than in the treated trees. Although azinphos-methyl was effective for control of other species of coneworms, it had not been applied early enough in the season to prevent damage by the webbing coneworm during 1980. Losses of strobili attributed to conelet abortion caused by unidentified factors or to attacks by unidentified insects were similar in both orchards.

Estimates of average number of seed per cone were about 35 percent higher for the treated than for the untreated trees and germination percentages about twice as high (table 2). The increased yield may have been the result of both decreased ovule abortion from control of seed bugs (DeBarr and Ebel 1974) with carbofuran and increased seed production per cone as a result of tree fertilization (Robinson 1979; Schmidtling 1975) and cultural practices. Significant differences were not found between treatments for percentages of seed classified from radiographs as damaged by seed bugs. The percentages of empty seed which also include some seed-bug damage, and the percentages of seed damaged by seedworms, Cydia spp., were significantly different between treatments, with the highest percentages occurring in the untreated orchard.

The combined use of insecticides, fertilizers, and cultural practices in

Table 1.--Comparison of female strobilus mortality on four clones of loblolly pine in an untreated (UT) orchard and in an orchard treated (TRT) with insecticides

Mortality factor	April 1979-Sept. 1980		March 1980-Sept. 1980	
	TRT	UT	TRT	UT
	Percent of initial flowers			
Webbing coneworm	33.5	0**	0	0
Other coneworms	22.2	51.6**	1.3	9.6*
Unidentified insects	0	1.6*	.8	.4
Unknown	27.9	25.9	13.1	16.9

Significant difference between treatment means: * = $P < 0.05$, ** = $P < 0.01$.

Table 2.-- Comparison of quantity and quality of seed produced from 1979-1980 on four clones of loblolly pine in an untreated (UT) orchard and an orchard treated (TRT) with insecticides

Seed quality	TRT[a] (80.5±10.9 seed/cone)[b]	UT[a] (59.6±7.5 seed/cone)[b]
	- - - Percent - - -	
Filled[c]	64.2	28.2**
Empty	29.4	54.6*
Seed-bug damaged	3.2	1.2
Seedworm damaged	1.0	10.7*
Fungus damaged	.9	3.1
Abnormal (unknown)	1.4	2.2
Germinated	56.1	25.2*

[a]Significant difference between treatment means: * = $P < 0.05$, ** = $P < 0.01$.

[b]Estimated mean values ± SE for groups of different numbers of cones collected from the same ramets.

[c]Significant differences ($P<0.05$) were found between clones.

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the treated orchard resulted in about twice as many mature cones per sample tree in 1980 with about three times as many viable seed per cone. Although the independent effects of fertilizers and cultural practices on seed yields were not determined, we assumed that differences in percentages of insect damage resulted from protection afforded by the insecticide treatments. An early spring application of carbofuran was not effective for control of the webbing coneworm on second-year conelets during 1980. Additional research is needed to explain the absence of webbing coneworm damage in the untreated orchard. The percentage of damage caused by other species of coneworms, however, was significantly lower on first- and second-year strobili produced by trees treated with carbofuran and azinphos-methyl. Seedworm damage was also 9.7 percent lower on trees treated with insecticides, which indicates that the May 1980 application of azinphos-methyl was effective against larvae when they are most vulnerable to insecticides (Merkel 1967).

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Southeastern Forest Experiment Station • 200 Weaver Boulevard • Asheville, North Carolina 28804

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